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Connections

Research

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Educating Indian Head's Future Customers

Anh Duong, the new Director for Science and Technology at NSWC, Indian Head Division (IHDIV), sees the growing ties with the U.S. Naval Academy as an important way to help fulfill IHDIV's mission. "When the current midshipmen graduate, they will become the Navy's next leaders. They will be our customers, the users of Indian Head's products. The research and education collaborations between the Academy and Indian Head help put us in touch with our future customers."

Duong notes that, in the past, Navy officers have not always been well versed in IHDIV's important technical contributions to the Fleet's advanced ordnance capabilities. "We are several layers removed from the Fleet. Of most immediacy to the officers and sailors are the platforms and systems they use every day. Many naval officers have tended to think that the underlying technologies that support those platforms and systems all came from private industry," Duong notes.

In fact, however, many of the technologies used by the Fleet today were invented in government laboratories — Indian Head among them — and subsequently transitioned to private industry. The research collaborations between IHDIV and USNA are making that fact more well-known among up-and-coming officers.

"Through cooperative research and education projects, we foster greater understanding within the Navy leadership of Indian Head's role," says Duong. "We are making the Fleet more aware of our role as a Naval technical institution that exists to understand the technical dimension of military problems and ensure that there will be a capacity to solve them. The more they understand our role and mission, the better we will be able to serve them."

From a purely educational perspective, the internships, visiting professorships, and faculty collaborations help "round out the midshipmen's job training by giving faculty and students more exposure to ordnance problems and research approaches," says Duong. "When they encounter an ordnance-related problem in the future, they will know whom to call." ➤

Inside

The directorship for Science and Technology (S&T) is a new position at Indian Head. Duong sees her primary responsibilities as "growing IHDIV's science and technology presence and contributing to the future Navy." Among other things, her job involves developing and coordinating IHDIV's corporate S&T strategy, managing S&T investments, and serving as the IHDIV focal point for headquarters, sponsors, partners, and others on S&T strategic matters.

From Duong's perspective as S&T Director, research and educational partnerships like the one between IHDIV and the U.S. Naval Academy are a critical link in securing the Navy's future technical superiority. ■

Coast-to-Coast Collaborations

IHDIV and USNA Forge Educational Ties With Naval Postgraduate School

The nexus between Navy research and education is generating new, mutually advantageous relationships among the Naval Postgraduate School (NPS) in Monterey, California, the Naval Surface Warfare Center, Indian Head Division, and the U.S. Naval Academy in Maryland. "The possibilities for collaboration are obvious," says Mike Scherr. Scherr himself pursued postgraduate training at NPS and is currently Director of Technology Transition at Indian Head.

According to James L. Kays, Dean of the NPS Graduate School of Engineering and Applied Sciences, research is an integral component of graduate level teaching and learning, where laboratory work fuels the creativity and questioning that are essential for advanced academic inquiry.

Chairman of the NPS Physics Department Dr. James Luscombe agrees, noting that collaborations with other members of the Navy scientific and engineering community provide additional research and teaching opportunities for NPS faculty and postgraduate students, while vastly enriching the scientific and technical resources supporting the Navy (including the USNA) and its mission. Luscombe provides two examples from the NPS faculty: Dr. Ron Brown and Dr. Bill Colson.

Physics of Explosives Course Goes Long Distance

Brown came out of retirement and joined the NPS faculty a year ago last May to teach a course in the physics of explosives. That course is offered in the traditional classroom/laboratory format to naval officers enrolled at the NPS. As a result of interest from Scherr and others at Indian Head, Brown is now in the process of developing a new distance learning course that can be offered anywhere in the country, including at both Indian Head and USNA.

Creating a distance learning course is a more complicated process than planning a traditional course, says Brown. An electronic course requires elements not often present in the classroom, such as animation and computer graphics to present the subject matter. The capability for an electronic dialogue between the instructor and students must also be devised, one that preferably functions like a bulletin board to allow a shared, although

not necessarily real-time, "conversation." Brown is receiving assistance from the NPS Learning Center to assemble the technical building blocks of the distance learning course.

At the same time, a distance learning course requires many of the same instructional elements as a classroom course, such as "remedial" or review material. This is necessary, says Brown, because postgraduate students have varied educational backgrounds — some may not necessarily have their bachelor's degree in physics, for example. Dr. Brown's distance learning course is being crafted with the needs of the advanced students — no matter where they are — in mind.

Brown expects to have the distance learning version of the course ready for launch sometime in 2004.

Physics of Explosives Course — Summary Description

The Physics of Explosives course at NPS, including the distance learning version, explores: the features of molecule bonding and dissociation that govern the energetics, stability, sensitivity, and detonation characteristics of explosives, thermophysics, and thermochemistry; reaction kinetics; shock and detonation theory; explosive initiation; hot-spot theory and importance of the failure diameter; explosive detection; and explosive applications.

The goal of the course is to provide students with a technical background for making decisions about new and existing explosives and explosive compositions, based on thermodynamic principles, molecular energetics, detonics, mechanical stability, safety, producibility, and cost.

This course may be available to be taken by midshipmen and instructors at USNA.

Directed Energy Back on the Burner

Directed energy weapons are tools that the current midshipmen could be using in the not-too-distant future. According to Colson, directed energy uses a high-power laser beam propagated through the atmosphere to shoot down a missile before it arrives at the site of detonation. The concept has been around for some 20 years, and its potential was demonstrated in the 1990s when a directed energy laser was successfully used to destroy incoming artillery shells. Investigators working on the concept believed that directed energy could be used, among other things, to destroy missiles that are attacking Navy ships.

Despite its promise, however, other technologies took priority when it came time to fund further research. As a result, directed energy stayed in the background until recently, when America's homeland defense needs became a top national priority.

The renewed interest in high-powered lasers as a missile defense technology has generated a joint technology program between the Naval Postgraduate School and the Air Force Institute of Technology at Wright Patterson AFB in Dayton, Ohio. Investigators are using simulations to understand how the laser beam "melts" or structurally breaks up part of the missile while it is in the air, enroute to its target.

Because of the potential that directed energy weapons will be deployed by the U.S. Navy Fleet within ten or fifteen years, the new cadre of naval officers will need to be knowledgeable about the technology. To that end, Colson is developing simulation software for use at the Naval Academy that will teach midshipmen about the physics of laser propagation and directed energy weapons. "We need to expose young naval officers coming onboard to laser propagation because they will likely be deploying directed energy weapons as a defensive tool in coming years," says Colson.

Computer-generated simulations are a very effective teaching tool, notes Colson. Students can

see how air turbulence can break up a laser beam, for example, or how much power is necessary to achieve the intended destructive effect on the target. The simulation software will be available to midshipmen working on problems or doing research work on laser propagation as part of their undergraduate studies.

Professors, Advisors, and Collaborators

The above are just two examples, according to Scherr, of the potential for cooperative ventures among the NPS, the Naval Academy, and NSWC, Indian Head Division. Scherr hopes to initiate visiting professorships at NPS for Indian Head researchers, many of whom are recognized leaders in their fields. Practicing scientists and engineers may also be interested in serving as thesis advisers for NPS students or as research collaborators, along with USNA faculty, for midshipmen's research projects or Trident Scholar projects. Scherr is laying the groundwork for these potential academic collaborations.

"We have a wealth of intellectual resources here at Indian Head and within our Navy laboratories and educational institutions. The more synergies we can find, the more prepared our next wave of officers will be," says Scherr.

Research collaborations and visiting professorships also benefit scientists and engineers working in the laboratory, Scherr believes. By working with students and rendering their knowledge as lecture notes, engaging in class discussions, and devising technical problems for discussion, they may encounter new understandings that will enhance their work in the laboratory. ■

Summer Internships

Exploding Opportunities: A Midshipman at Indian Head

"It was a blast," said Midshipman First Class Patrick Sneed of his four weeks at Indian Head as a 2003 summer intern. He meant that in more ways than one. Sneed, a chemistry major at the U.S. Naval Academy, got some valuable "hands-on research time" as he geared up for his senior research project during his last year at the Academy.

"I will be building a computer model of shock wave propagations for my senior project," said Sneed. Working on a summer internship with the Dynamic High Pressure Physics and Chemistry Group at NSWC Indian Head, under the direction of Dr. Gerry Pangilinan, allowed Sneed to "see the actual physical results of explosions in a bomb-proof room," he said. As he constructs his model, that sort of real-world observation will provide Sneed with insight that is rare for an undergraduate student. Sneed's research advisors at the Naval Academy are Associate Professor Christopher M. Kinter and Professor Mark L. Elert of the Chemistry Department.

During his four-week internship at Indian Head, Sneed worked primarily under the supervision of Dr. Scott Miller. The project involved monitoring transient chemical species in detonations using time-resolved emission spectroscopy with sub-microsecond resolution (see the box on page 5 for a technical description of the project). The

work is related to ongoing thermobarics research conducted at Indian Head and supported by the Defense Threat Reduction Agency (DTRA).

Supporting Internships

Last spring, upon being informed of Sneed's interest in modeling shock propagation and chemical reactions in solids, Pangilinan was "thrilled to hear this from anybody, an undergrad at that!" The experiments he participated in at Indian Head "gave him a feel and a necessary intuition to understand and control shocks," says Pangilinan, an outcome that he called "very promising."

While at NSWC, Indian Head Division, Sneed lived in the bachelor officers' quarters, accommodations he called "great," and ate at the officer's mess hall. According to Dr. Sue Peiris, the USNA-IHDIV Research Liaison who sets up the arrangements at Indian Head, herself a research chemist, said, "We are very pleased with how the summer internship worked out, and we look forward to extending more summer internship opportunities to rising senior midshipmen in the future."

Peiris emphasizes the mutual benefits of these research interactions. The midshipmen get first-person experience in a Navy lab, reinforcing classroom work and providing a transition to their senior research project. At the same time, Indian Head has the opportunity to acquaint the Navy's future leaders with its vital role in energetics research and development in support of the Fleet. This link will provide many future dividends for Navy science and technology and, ultimately, the warfighter.

Peiris is seeking intern sponsors at Indian Head for the summer of 2004. Peiris may be reached at PeirisSM@ih.navy.mil. Midshipmen should express their interest in summer internships at Indian Head to Professor Joyce E. Shade, Deputy Director of Research and Scholarship, at shade@usna.edu. ■

Real Time Spectroscopic Diagnostics of Explosive Events

Intern: MIDN 1/C Patrick Sneed
IHDIV Sponsors: Dr. Gerry Pangilinan and Dr. Scott Miller

Measurements of explosive energy release in real time are critical in many Navy applications, particularly when specific tailored energy release is desired. Such measurements have traditionally been difficult to carry out because explosive energy release characteristically occurs at fast time scales and at extreme conditions of temperatures and pressures. State-of-the-art time-resolved laser-based spectroscopic techniques are now being developed at Indian Head to monitor shock pressures and temperatures, shock propagation, and shock-induced chemistry from explosives.

The focus of the work was to use spectroscopic techniques to measure chemistry, probe temperature, or measure associated shock propagation from a selected small-scale (~ 20 g) explosive detonated at the bomb-proof facilities at Indian Head. Results obtained were compared to those of other explosives for performance evaluation.

Research Connections is published periodically to provide information about ongoing and potential research collaborations between Indian Head and the Naval Academy.

For more information:

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The Next Wave: Trident Scholar Program

Through the Trident Scholar Program, the United States Naval Academy recognizes and supports the Navy's future scientists and engineers by giving them the opportunity to work on a self-defined problem in close consultation with one or more faculty advisors. The program has served as an incubator for the next generation of Navy leaders, having produced numerous high-ranking officers since its inception in 1963.

The following list of recently graduated 2003 Trident Scholars is intended to give the Navy's scientific community an idea of the depth and sophistication of the midshipmen's projects and interests. For more information on the Trident Scholars Program, contact Professor Joyce E. Shade at 410-293-2509 or shade@usna.edu. IHDIV scientific and engineering staff interested in serving as collaborators to midshipmen and Naval Academy faculty involved in the Trident Scholars Program should contact Sue Peiris at 301-744-4252 or PeirisSM@ih.navy.mil. ■

Class of 2003 Trident Scholars

MIDN 1/C Matthew J. Ahlert
Major: Mathematics
Advisors: Associate Professor John F. Pierce, Mathematics Department; Professor Reza Malek-Madani, Mathematics Department
Project: Multiresolutional Optic Flow

MIDN 1/C Tyler H. Churchill
Major: Physics
Advisor: Professor Jeffrey R. Vanhoy, Physics Department
Project: Investigation of Tellurium-130 Nuclear Structure Using Inelastic Neutron Scattering

MIDN 1/C Kristen L. Deffenbaugh
Major: Mechanical Engineering
Advisors: Assistant Professor Michelle A. Koul, Mechanical Engineering Department; Associate Professor Angela L. Moran, Mechanical Engineering Department
Project: Environmentally Assisted Cracking Properties of AA7249 Extrusions for Aerospace Applications

MIDN 1/C Jeffrey H. Dormo
Major: Electrical Engineering
Advisors: Associate Professor R. Brian Jenkins, Electrical Engineering Department; Professor Martin E. Nelson, Mechanical Engineering Department
Project: Optical Calibration of TLD Readers

MIDN 1/C Luke R. Dundon
Major: Physics
Advisor: Associate Professor Debora M. Katz, Physics Department
Project: Physical Properties of Near-Earth Objects: Optical and Infrared Astronomical Observations

MIDN 1/C Nathan A. Fleischaker
Major: Electrical Engineering
Advisor: Captain Joseph C. McGowan, USNR, Electrical Engineering Department
Project: Wireless Network Design Optimized for Military Operations in Degraded Littoral Environments Using Anticipatory Link Layer Error Detection Mechanisms

MIDN 1/C Katherine E. Groenenboom
Major: Aerospace Engineering
Advisors: Dr. Richard P. Fahey, Visiting Professor, Aerospace Engineering Department; Professor Daryl G. Boden, Aerospace Engineering Department
Project: Determination of Atmospheric Density in Low Earth Orbit Using GPS Data from the USNA Satellite

MIDN 1/C Philip C. Hoblet
Major: Systems Engineering
Advisors: Associate Professor Richard T. O'Brien, Jr., Weapons and Systems Engineering Department; Assistant Professor Jenelle L. Piepmeier, Weapons and Systems Engineering Department
Project: Scale-Model Vehicle Analysis for the Design of a Steering Controller

MIDN 1/C Kenneth J. Hoover
Major: Electrical Engineering
Advisors: Professor Antal A. Sarkady, Electrical Engineering Department; Commander Charles B. Cameron, USN, Electrical Engineering Department
Project: A Bluetoothed-Based Wireless Network for Distributed Shipboard Control and Monitoring Systems

MIDN 1/C Bryan M. Hudock
Major: Systems Engineering
Advisors: Associate Professor Bradley E. Bishop, Weapons and Systems Engineering Department; Assistant Professor Frederick L. Crabbe, IV, Computer Science Department
Project: Development of an Urban Search-and-Rescue Robot

MIDN 1/C Eric H. Larsen
Major: Mechanical Engineering
Advisors: Associate Professor Martin R. Cerza, Mechanical Engineering Department; Assistant Professor Andrew N. Smith, Mechanical Engineering Department
Project: A Capillary-Assisted Thermosyphon for Shipboard Electronics Cooling

MIDN 1/C Michael Oliver
Major: Aerospace Engineering
Advisor: Professor Gabriel N. Karpouzian, Aerospace Engineering Department
Project: The Aeroelastic Effects of Transverse Shear Deformation on Composite Wings in Various Flow Regimes

MIDN 1/C Sean A. Patterson
Major: Systems Engineering
Advisors: Professor Kenneth A. Knowles, Weapons and Systems Engineering Department; Associate Professor Bradley E. Bishop, Weapons and Systems Engineering Department
Project: A Study of Magnetically-Coupled 2-D Reconfigurable Modular Robots

MIDN 1/C Jon P. Silverberg
Major: Naval Architecture
Advisor: Assistant Professor Paul H. Miller, Naval Architecture and Ocean Engineering Department
Project: Ship Performance Prediction Methods with Respect to Tank Testing and Computational Fluid Dynamics

MIDN 1/C Joseph F. Sweger
Major: Aerospace Engineering
Advisor: Captain Robert J. Niewoehner, USN, Aerospace Engineering Department
Project: Design Specifications Development for Unmanned Aircraft Carrier Landings: A Simulation Approach

MIDN 1/C David L. Zane
Major: Mathematics
Advisors: Assistant Professor William N. Traves, Mathematics Department; Assistant Professor Christopher W. Brown, Computer Science Department
Project: Efficient Academic Scheduling at the U.S. Naval Academy

Spotlight on Collaborative Research

Synthesis of High-Energy Gem-Difluoramine Compounds for Improved Explosive and Propellant Formulations

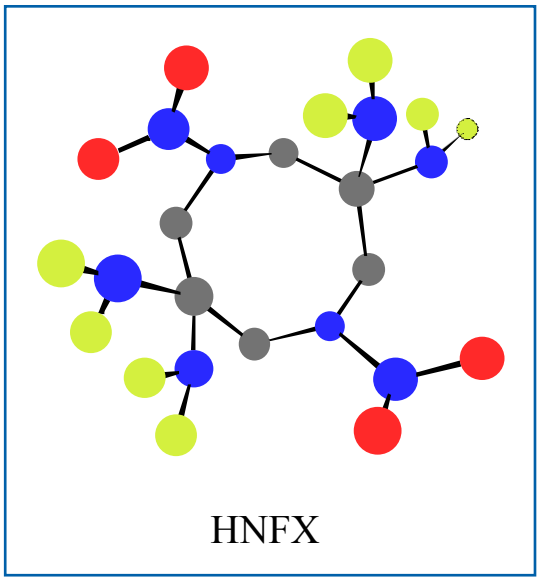
Dr. Christopher M. Kinter
Associate Professor
USNA Chemistry Department

The study of the synthesis and reactivity of compounds containing nitrogen-fluorine bonds began in the 1950s when it was realized that such compounds had potential advantages over the known oxidizers of the time. Much of the advantage in the difluoramino compounds comes from their highly exothermic chemical decomposition into low molecular weight products (i.e., hydrogen fluoride (HF), carbon monoxide (CO), carbon dioxide (CO_2), and nitrogen (N_2)) that contain relatively strong bonds, and the ability of liberated fluorine to rapidly attack metal-containing solid explosives and propellants.

Many chemical methods have been developed for the introduc-

tion of geminal difluoramino groups into organic compounds using either elemental fluorine (F_2) or other fluorine transfer reagents. However, these methods generally suffer from low conversion to the desired compounds and often require extreme caution in handling the potentially hazardous chemicals. For example, the first synthesis of HNFX was reported by Baum and coworkers in 1991 and resulted in the production of HNFX in less than 1 percent yield. Chapman and coworkers at NAWC-CL in 1999 reported an improved synthesis of HNFX and the first synthesis of RNFX. These early synthetic efforts took advantage of the reaction of difluoramine (HNF_2) with the corresponding ketone precursors.

However, this "classical" method for the introduction of geminal difluoramino functionality into organic compounds suffers from long reaction times and relatively harsh, strongly acidic reaction conditions that are required for the conversion of the precursor compounds into the desired target compounds HNFX and RNFX. Additionally, difluoramine is a thermally unstable, gaseous compound which is extremely sensitive to inadvertent initiation and therefore requires great care in its use. Due to the relatively low yields of the desired compounds and the difficulties in handling difluoramine, alternative approaches for the multigram production of organic compounds containing geminal-difluoramino functional groups are currently being investigated for use in the improved synthesis of HNFX and RNFX.



HNFX

Dr. Kinter's work with Dr. Stern and Dr. Mannion has focused on exploring the feasibility of using a diaziridine ring in the synthesis of the geminal difluroamine functional groups. The diaziridine group is a three membered ring containing two nitrogen atoms. The diaziridine ring can be easily prepared by a number of methods using inexpensive reagents. Additionally, there is literature precedence for the conversion of nitrogen containing functional groups such as carbamates and amides into difluoramine products on reaction with elemental fluorine. Using this strategy to produce the geminal difluoramine functional groups present in HNFX or RNFX would require the preparation of geminal dicarbamates or geminal diamides, both difficult-to-prepare functional groups.

Essentially, Dr. Kinter's research is exploring the possibility of using the diaziridine ring as the synthetic equivalent of geminal dicarbamates or geminal diamides. This approach would be advantageous over the classical approach to difluoraminations in that it avoids the use of hazardous HNF_2 and does not require highly acidic reaction conditions. If this approach is successful, then it should allow the preparation of sufficient quantities of the target compounds to allow testing to determine the practicality and suitability of these materials for use in explosive and propellant formulations. ■

(Note: Such testing will be done at Indian Head; only non-explosive steps in the chemical research are undertaken at USNA.)

Dr. Chris Kinter has been participating in an Office of Naval Research-sponsored research project for the past several summers with NSWC-IHDIV Principal Investigator Dr. Alfred G. Stern and, last summer, ASEE postdoctoral fellow Dr. Joseph Mannion. The objective is to establish new, efficient synthetic methods for the preparation of high energy density oxidizers containing both nitramine and geminal-difluoramino functionality. The specific target molecules for synthesis include HNFX and RNFX, which are geminal difluoramino analogues of HMX and RDX, respectively.